Improved Techniques for Core Handling to Enhance Subsurface Site Assessment

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Abstract

Recent improvements in the basic principles of core handling and processing that are outlined in API RP-40, *Recommended Practice for Core Analysis* (API, 1998), Fig. 1 and ASTM D5079, *Standard Practices for Preserving and Transporting Rock Core Samples* (ASTM, 1990) have resulted in successfully processing and analyzing over 15,000-ft (4572-m) of unconsolidated core from Superfund and petroleum release sites. This paper presents methods for field preservation, transportation and analyses on unconsolidated core samples. Examples of high-resolution photography, both color and ultraviolet for hydrocarbon fluorescence are discussed.

Appropriate core handling and processing procedures are essential to define correct depth allocation, maintain core integrity, preserve core properties, ensure petrophysical measurements are representative of subsurface conditions and to provide photographic documentation. As the environmental industry grows and matures, technology advances enable consultants and engineering firms to use more sophisticated techniques for gathering representative data. One of these techniques is borrowed from the petroleum industry and consists of taking undisturbed subsurface core samples for petrophysical properties and sequence stratigraphy.

In order to minimize damage done to cores and to maximize the accuracy of data received from the core, several choices must be made for a coring program. Based upon requirements of the core analysis program (determined by site assessment/remediation design), there are many options for processing the subsurface core. These choices must include plans for maintaining core physical integrity, chemical properties and fluid retention as well as preservation and transportation methods to ensure that critical core properties are not altered. Photographic documentation of the core must be made to provide a historical record for future use, regulatory requirements, litigation and engineering purposes.

Discussion

Study and analysis of subsurface soil and rock (core analysis) is a science pioneered by the petroleum industry. As the environmental remediation industry has grown and matured engineers and scientists realized that technology and methods used to maximize recovery of petroleum from reservoirs could also be applied to removing contaminants and hazardous wastes from soil. The main difference applying the technology is in the scale of the process being studied. The petroleum industry analyzes cores (rock) taken from great depth and then studied for storage capacity and recovery potential of large volumes of crude oil and natural gas. The environmental assessment and remediation industry analyzes subsurface core (soil) taken from shallow depth and then studied for effective removal of contaminants and remediation efficiency. Core handling and analysis, the most effective technology used for studying hydrocarbon, water and other types of transport or removal from the subsurface and is common to both industries.

Continuous core is arguably the most valuable asset of any sub-surface investigation. Only core can physically provide the actual measured data needed for any geologic or engineering study. Proper handling in the field and long term preservation of subsurface core gives geologists and engineers the ability to answer immediate and future questions. Several standards and guidelines exist for the proper handling of subsurface core. The current edition of *API RP-40, Recommended Practices for Core Analysis* was revised in 1998 and provides the fundamentals and methods for proper core handling, processing and analyses as well as the most technologically advanced methods accepted by the petroleum and environmental industry. Included are sections on Planning a Coring Program, Wellsite Core Handling Procedures and Preservation, Core Screening and Core Preparation, and Core Analyses. *ASTM D 5079, Standard Practices for Preserving and Transporting Rock Core Samples* covers practices for preservation, transportation, storage, cataloging, retrieval and post-test disposition of rock core (soil) samples obtained for geologic study and core analysis. Use of these two standards can help engineers and geologists to design a comprehensive data gathering (coring program) that is legally defensible, provides the high quality data needed to define remedial parameters and assist in negotiation with regulators. Our coring programs have resulted in successfully processing and analyzing over 15,000-ft (4572-m) of unconsolidated core from Superfund and petroleum release sites.

Core Program Case Study

Project was a Superfund site in the Los Angeles basin and continuous coring of multiple borings was used to establish detailed site stratigraphy for the RI/FS phase. Total footage for the project approached 12,000-ft (3700-m). PTS GeoLabs established procedures for handling and preserving the unconsolidated sediments.

General depositional setting is marine to continental with several environments; alluvial fans, deltas and estuaries containing complex deposits. Beds are essentially flat with the top of the Gauge aquifer in the Lakewood Formation dipping less than 1° to the northeast. Deposits range from gravel to massive clay in interbedded sequences a few inches to many feet in thickness. Detailed description of the sequences was required to identify potential contaminant pathways.

Coring

Cores were taken using a mud-rotary rig with a standard 2-in (5.08-mm) unlined split sampler. Mud-rotary was used to limit potential of cross-contamination between water bearing zones. Circulating drilling mud will potentially cake over the bore hole reducing permeability, porosity and communication in the formation. All cores were unconsolidated and required an integrated effort between drillers, core handlers and geologists to achieve maximum recovery and minimal disturbance.

Core Handling

PTS GeoLabs was tasked with removing the core from the sampler, maintaining accurate core depth logs, preserving the core and transportation to the fixed laboratory facility. Cores were taken continuously from the surface to final depth and typically represented 35-60-ft (11-18-m) of unsaturated sediment grading to 55-135-ft (18-41-m) of saturated sediment.

Cores were rapidly brought to the surface, immediately placed in a horizontal position and removed from the drill rod. The core handling technician removed the shoe and carefully raised one section of the split tube high enough to insert a thin-wall Core Removal Tool (CRT) between the inner wall of the tube and core (see Figure 1). The CRT was carefully slid the length of the tube while simultaneously lifting the tube section to separate it from the core surface. This preserved the integrity of the core by preventing it from sticking to the inner surface of the tube. A section of clean PVC tubing that had been cut lengthwise in half, and annotated with top and bottom depths, was placed on the exposed core surface. While firmly holding the PVC to the core surface, the core handling technician carefully axially rotated the PVC, core and tube 180° so that the tube was facing upward. The CRT was again used to separate the tube from the core surface. The small core section was removed the shoe and placed on the PVC core support at the bottom of the core interval.

The core section was measured to the nearest 0.1-ft (0.03-m) and the recovered length was recorded along with attempted cut. Over recovery occasionally occurred, usually in clayey intervals, and was recorded and added to the top of the next cored interval. The site geologist made preliminary field description of the core. Core saturations and structural integrity were preserved by wrapping with Saran ™ film and placing in a freezer crate containing dry ice. Core was collected throughout the day and transported to PTS GeoLabs at the end of the shift.

Core Processing

Preserved cores were cut (slabbed) lengthwise into 1/3 by 2/3 sections using an automatic feed horizontal bandsaw with a diamond segmented blade (see Figure 2). Feed was adjusted to minimize disturbance of the core. Liquid nitrogen vent gas was used to cool the blade and prevent volatilization of pore fluids. The 1/3 section (slab) was placed on a PVC support and a detailed description performed by the site geologist. The 2/3 section (bulk) was preserved for petrophysical (porosity, permeability, saturations and grain size) analysis.

Core Photography

Core photography was employed to provide a permanent record of the subsurface structure for RI/FS program (see Figure 3). Core slabs were laid out, side by side, on a photographic stage and shot using white light and 25 ASA color print film. A Pentax 6x7 camera with a SMC Pentax 67 105mm f-2.4 lens at f-16 suspended above the core surface provided sufficient resolution. Depending on the level of interest, photographs showed

24-ft (0.73-m), 12-ft (3.7-m) or 1-ft (0.31-m) of core per print. Zones of contamination were shot under a combination of short and long wave ultraviolet light to show hydrocarbon fluorescence.

Petrophysical Analysis

locations were identified for petrophysical analysis using the core photographs. Samples were cut from the bulk core sections and analyzed for porosity, hydraulic conductivity, saturations, moisture and bulk density. Vertical conductivity measurements were made to identify flow barriers. Additional measurements were made for particle size distribution by sieve and laser light scattering.

Recommendation

Adopting an integrated plan for coring, core handling and analysis will provide valuable insight to the subsurface structure. With this knowledge cost effective remediation or engineering can be proposed.

Following are recommended field procedures for handling, preserving and shipping unconsolidated cores obtained from shallow borings. Coring methods are beyond the scope of these procedures as every site will have it's own unique problems and is best addressed by the consultant and coring companies involved.

1. Make core recovery the goal of the field sampling phase of the project and not the amount of hole cut.
2. Remove sample from core sampler as soon as possible.
    a. If core is in sleeves, fill any void space with saran wrap to minimize core movement then seal with Teflon ™ film and tape on plastic end caps.
    b. If core is not in sleeves slide gently from sampler on to split PVC core supports. Wrap with Saran™ and secure with clear box tape.
3. Label each core section with top and bottom depths. Fractions of a foot should be recorded in tenths. Additionally label multiple sleeves sequentially with A, B, C...etc starting with A on the top (shallowest) sleeve.
4. Immediately place cores in a cooler containing dry ice and freeze to minimize migration of core fluids. Alternate methods may be used for preservation depending on test program goals.
5. Prepare samples for transportation using methods to minimize vibration, shock and temperature change.
6. Ship cores at the end of each shift to core analysis laboratory for processing.

Remember: The better quality of the core, the better quality of the data.

References

1. *API RP-40, Recommended Practices for Core Analysis*, second edition, American Petroleum Institute, Washington, DC (1998).

2. *ASTM D 5079, Standard Practices for Preserving and Transporting Rock Core Samples*, American Society for Testing and Materials, Philadelphia, (1996).

Figure 1. Using thin-wall Core Removal Tool (CRT) to separate core from split spoon sampler. Use of the CRT retains the integrity of the core.

Figure 2. Preserved core being slabbed by PTS automatic feed horizontal bandsaw. Diamond segmented blade cuts through brass, steel and cobbles alike while preserving core integrity and internal structure.

Figure 3. Slabbed core being prepared for lithological description and photographic documentation. Note that internal core structure is undisturbed.

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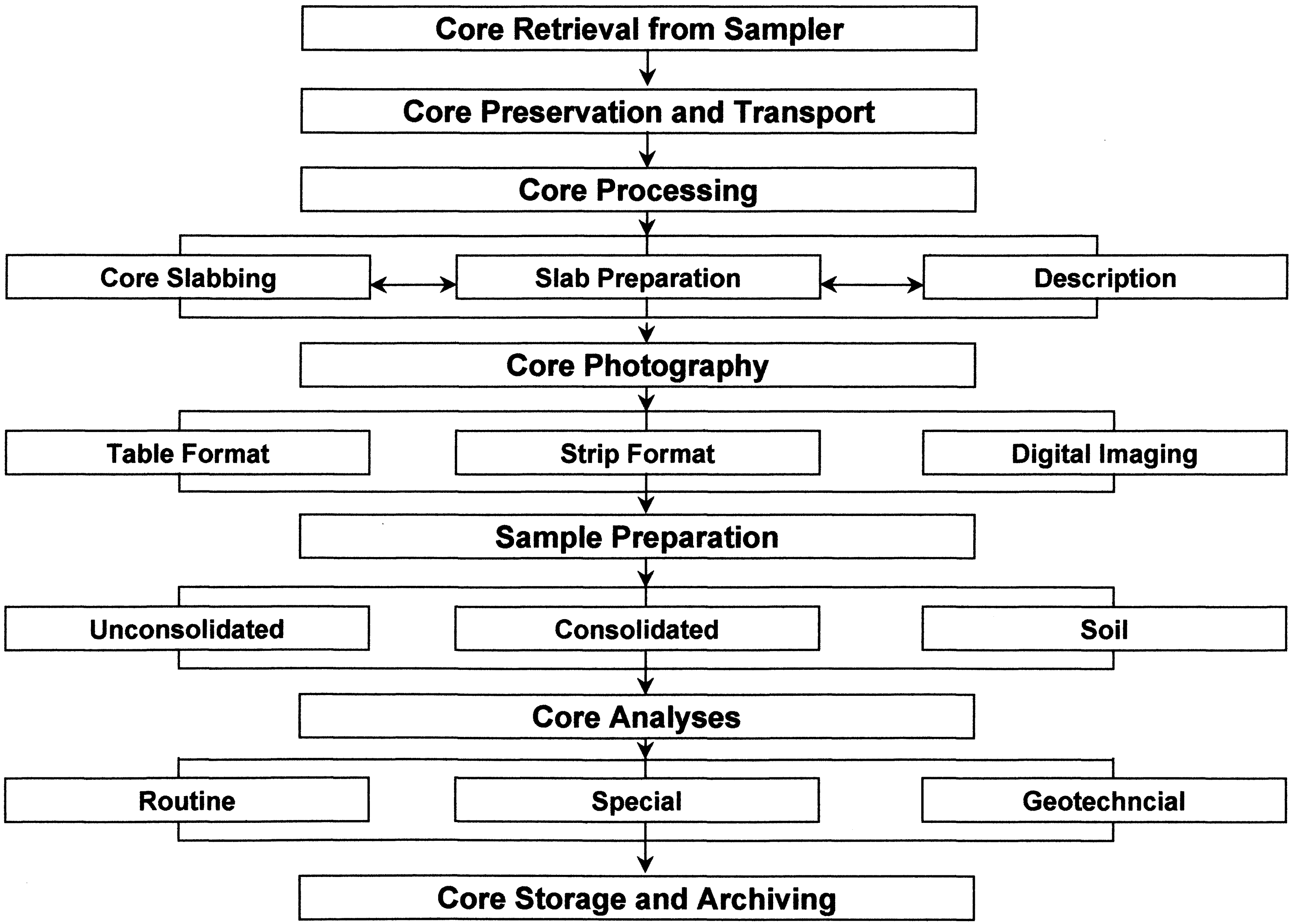
Subsurface Core Program Flow Chart



After; *API RP-40, Recommended Practices for Core Analysis,* second edition, American Petroleum Institute, Washington, DC (1998) and *ASTM D 5079, Standard Practices for Preserving and Transporting Rock Core Samples*, American Society for Testing and Materials, Philadelphia, (1996).